1

SUPERVISOR'S USE ONLY

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 1 Science, 2011

90940 Demonstrate understanding of aspects of mechanics

9.30 am Monday 21 November 2011
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of mechanics.	Demonstrate in-depth understanding of aspects of mechanics.	Demonstrate comprehensive understanding of aspects of mechanics.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Show ALL working.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–13 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 30

ASSESSOR'S USE ONLY

You may find the following formulae useful.

$$v = \frac{\Delta d}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t} \qquad F_{net} = ma \qquad P = \frac{F}{A}$$

$$\Delta E_p = mg\Delta h \qquad E_k = \frac{1}{2}mv^2 \qquad W = Fd \qquad P = \frac{W}{t}$$

The value of g is given as 10 m s^{-2}

You are advised to spend 60 minutes answering the questions in this booklet.

ASSESSOR'S USE ONLY

QUESTION ONE: PARACHUTING

A parachutist of mass 75 kg jumps from a plane at a height of 4 000 m above sea level.

(a) The parachutist falls through a distance of 2 400 m during the first 60 seconds. Calculate the average speed of the parachutist during this time.

$v = \frac{\Delta d}{\Delta t}$

$= \frac{2400}{60}$

$= 40 \text{ m s}^{-1}$

Average speed = 40 m s^{-1}

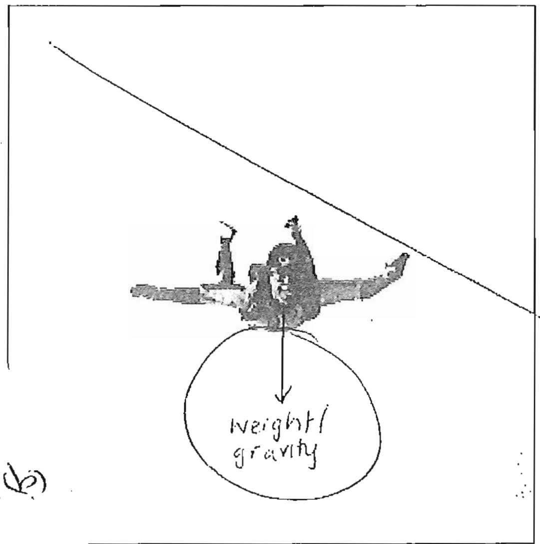
For copyright reasons, this image has not been reproduced here.

http://riverdaughter.files.wordpress.com/2009/07/free-fall1.jpg

(b) Explain the vertical motion of the parachutist **just after** she jumps out of the plane (before the parachute opens).

In your answer you should:

- draw and label the verti... on the parachutist an... s on the ima...
- de...
- d...
- exp... verti...



Student has a clear understanding of the situation. As shown by the 3 diagrams. very few students showed force diagrams with a ... Usage of the 3 diagrams covered all the required for part (b). Few words required. Excellent student answers. Want to see more student answers with diagrams using ...

When the p... immediately accelerates

When the p... immediately accelerates

down to the e... unbalanced, with

f weight/gravity

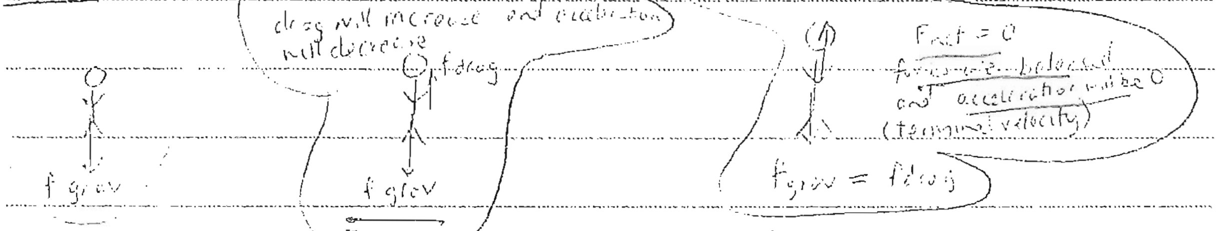
The net force is downwards and accelerating down

Fnet = down

At first

After a while drag will increase and acceleration will decrease

After a time Fnet = 0 forces are balanced and acceleration will be 0 (terminal velocity)



ASSESSOR'S USE ONLY

(c) After the 60 seconds, the parachutist pulls the cord and opens her parachute.

For copyright reasons, this image has not been reproduced here.

http://www.wallpaper-free.eu/wallpapers/parachute/parachute001_1400x1050.jpg

Explain how the parachute reduces the speed of the parachutist when it is just opened.

In your answer you should consider:

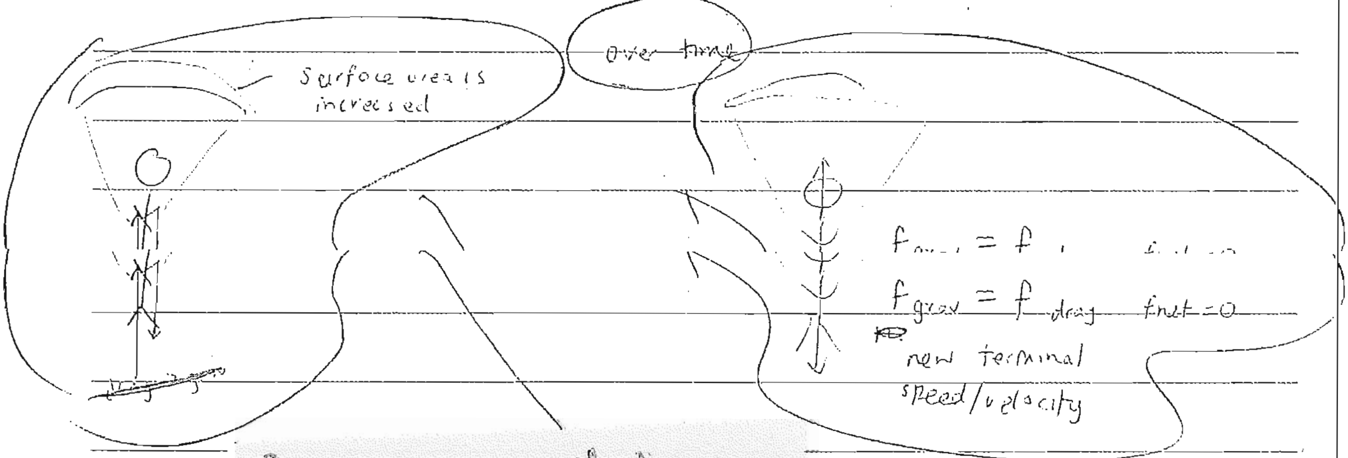
- how the motion of the parachutist changes when the parachute is opened
- the effect of the size of the parachute on the motion
- the effect of the parachute on the net vertical force.

When the parachute opens, there is more surface area for air to hit ∴ drag will increase. ($F_{drag} > F_{grav}$) & Eventually (after a time $F_{grav} = F_{air}$) the gravity ~~and air resistance~~ will ~~be~~ also increase and be balanced with air resistance, and parachutist will reach a new terminal velocity

when (Net force = 0)

~~When~~ (An object will remain at constant speed or at rest unless an external force acts) in this case, opened parachute is

& parachutist will slow down



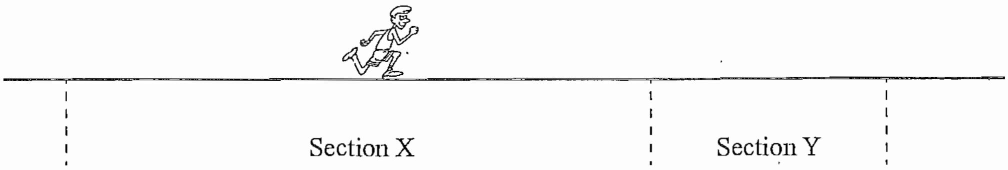
Again good use of diagram to show conceptual physics

Excellent answer and is what is expected for E8. The students will get this grade if they logically explain step by step the sequence of events.

E8

ASSESSOR'S USE ONLY

QUESTION TWO: RUNNING



A boy runs along a track, as shown above.

During section X, he runs with a **constant speed** of 2 m s^{-1} for 15 seconds.

During section Y, he runs with a **constant acceleration** of 0.2 m s^{-2}.

(a) Calculate the net force acting on the boy (mass 60 kg) during **section Y**.

Give an appropriate unit with your answer.

$F = ma$

$F = 60 \times 0.2$

$= 12$ N

Net force acting on the boy during section Y = 12 (N) unit

(b) The boy runs 12.5 m during section Y in 5 seconds.

Calculate the power required by the boy to produce the constant acceleration of 0.2 m s^{-2} in 5 seconds during section Y.

Give an appropriate unit with your answer.

$W = fd$

$W = 12 \times 12.5$

$= 150$ J

$P = \frac{W}{t}$

$= \frac{150}{5}$

$= 30$ W

Power required by the boy during section Y = 30 (W) unit

Clear understanding
Good layout of answer.

(c) (i) Calculate the speed of the boy as he reaches the end of section Y.

$v = \frac{d}{t}$ $= \frac{12.5}{5}$ $= 2.5\ m\,s^{-1}$

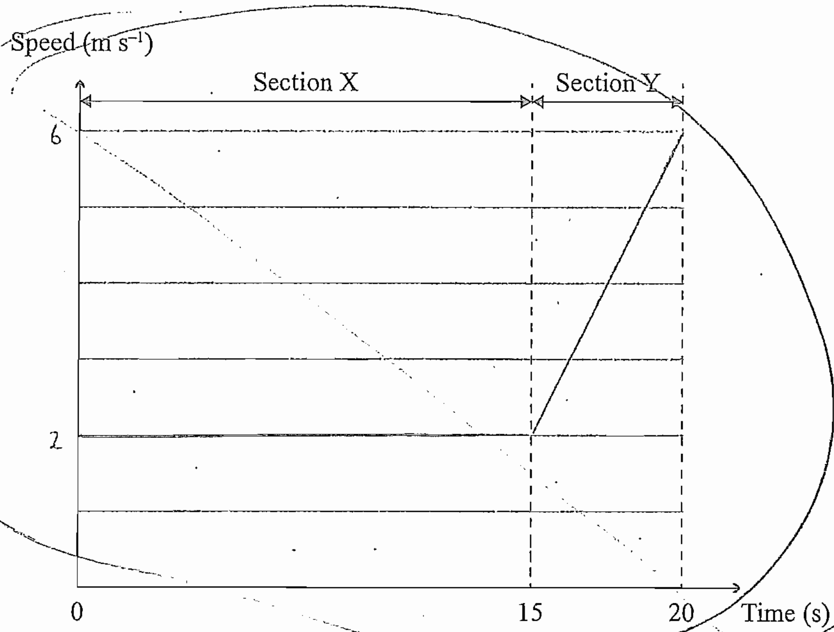
$v = a \times t$ $= 0.2 \times 5$ $= 1$ | speed at X + velocity Y $= 2 + 1$ $= 3\ m\,s^{-1}$

Speed at the end of section Y = 3 m s^{-1}

(ii) Use this and the other information provided in the question to complete the speed/time graph below.

On your graph, you should:

- label the speed values on the vertical axis
- draw a line on the graph to show the speeds for section X and section Y.



If you need to redraw this graph, use the grid on page 12.

Go to page 12

Y = $a = \frac{\Delta v}{\Delta t}$

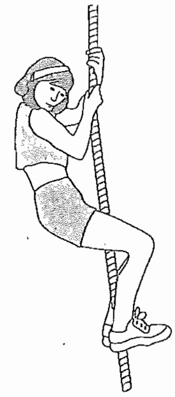
$v = a\Delta t$
$= 0.2 \times 5$
$= 1$

Calculate a correctly
well laid out
formula + calcs.

ASSESSOR'S USE ONLY

ASSESSOR'S USE ONLY

QUESTION THREE: ROPE CLIMBING



A girl of mass 60 kg uses 5 100 J of energy when she climbs a vertical rope.

(a) Calculate the maximum height it would be possible for the girl to reach.

$E_{p\,grav} = mgh$

$h = \frac{E_p}{mg}$

$h = \frac{5100}{60 \times 10}$

$= 8.5\text{m}$

Student first calcs $E_p = 4800J$ then calcs $Wd = 4800J$ calcs $\Delta E = 300J$ Heat from girl in form of friction. Not quite an E8 because no explicit statement $E_p = W$ (Implied though) & no discussion on source of heat energy other than friction force. – No mention of girl getting hotter

E7

(b) In reality, the girl reaches a height c

Explain why the **energy** used by th

the work she does to reach the vert

In your answer you should:

- name the type of energy the
- calculate the work done to re
- calculate the difference betw ... e girl
- explain where the "missing"

When the girl is 8m from the ground, she has gained gravitational potential energy. This is $E_p = mgh$, $E_p = 60 \times 10 \times 8 = 4800J$

Kinetic energy is required for the girl to climb the 8m this work done is

~~$E_k = \frac{1}{2}m$~~ $W = Fd$

$= 60 \times 10 \times 8$

$= 4800J$

– The difference between work done and energy used by girl is $5100 - 4800 = 300J$

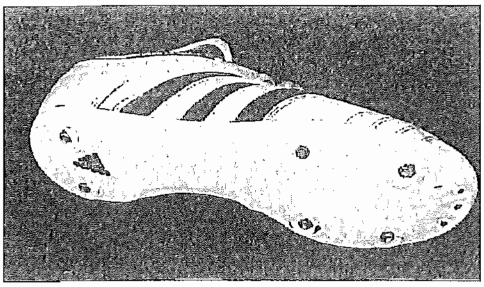
The law of conservation states that energy cannot be created or destroyed. It can only be transferred from one form to another.

– Realistically the 300J difference is lost through other forms of energy such ~~as by~~ as friction between the girl and rope and air resistance between girl and air from climbing up the rope

ASSESSOR'S USE ONLY

ASSESSOR'S USE ONLY

QUESTION FOUR: FOOTBALL BOOTS



Boot **without** studs.

Boot **with** studs.

A student of mass 40 kg uses the football boots shown above.

ONE boot **without** studs has a surface area of 165 cm^2 (0.0165 m^2) in **contact** with the ground.

ONE boot **with** six studs has a surface area of only 6 cm^2 (0.0006 m^2) in **contact** with the ground.

(a) Calculate the pressure exerted if the student stands on ONE foot on a **hard surface**, for the boot **without** studs AND for the boot **with** studs.

Give an appropriate unit with your answers.

(i) Without studs: $P = \frac{F}{A}$

$= \frac{40 \times 10}{0.0165}$

$= 24242.4$ Pa / Nm^{-2} (1dp)

Pressure exerted by ONE foot for the boot **without** studs = 24242.4 (Pa) unit

(ii) With studs: $P = \frac{F}{A}$

$= \frac{40 \times 10}{0.0006}$

$= 666666.7$ Pa / Nm^{-2} (1dp)

Pressure exerted by ONE foot for the boot **with** studs = 666666.7 (Pa) unit

(b) Discuss the advantage gained by the student when running on a soft grass football field while wearing the boots with studs compared to wearing boots of the same size without studs.

In your answer you should:

- compare the pressure exerted on the ground by the boot with the studs AND the boot without studs
- explain the relationship between surface area and pressure exerted
- explain how the difference in pressures would help the student run on a softer surface like grass.

– The pressure exerted on the ground by the boot with the studs exerts a significantly greater pressure than the boots without the studs. ($\frac{666\,666.7}{24\,242.4}$ ≈ 27.5 times more pressure)

Pressure = $\frac{\text{Force}}{\text{Surface Area}}$

– If force remains constant and surface area (S.A) is increased, then pressure is decreased (likewise if S.A is decreased, pressure is increased)

– The boots in studs have more of an advantage on soft grass due to having more pressure exerted on the ground, allowing better traction on the soft grass (and less friction) football field

The boots without studs exert less pressure, therefore are not as good because the greater surface area is more prone to slipping

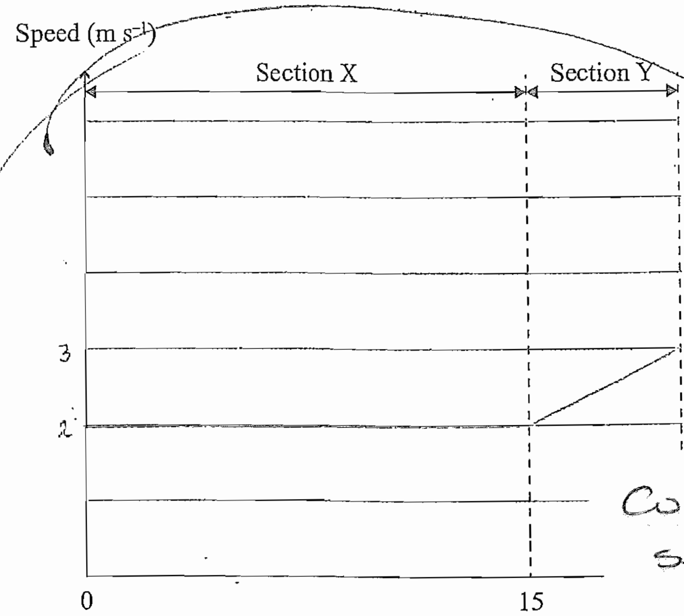
∴ Boots with studs have an advantage when running on a soft grass football field

"less friction" for studded boots lowered score.

ASSESSOR'S USE ONLY

ASSESSOR'S USE ONLY

If you need to redraw the graph from Question Two (c), draw it on the grid below. Make sure it is clear which graph you want marked.



Mark this graph, please (not the other one)

Correct graph shape so E8 awarded

Seen